Aviation Human Factors: Lessons from the Ashes

Robert Sumwalt

May 8, 2019

Human factors is a multidisciplinary science that examines the relationship between humans and the systems with which they interact, including…

Ergonomics
Engineering
Psychosocial interactions
Decision-making
TEM
Fatigue
Psychology
Physiology
Human-centered design
Biomechanics
Information processing
National cultural influences
Medicine
Study of organizational issues
Anthropometrics
CRM
Resilience engineering
Automation management
Communications

NTSB

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NTSB Medical Officers

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Medical Officer

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Medical Officer

NTSB Investigations Examine the Entire System

The Human(s)

Interface with Machine & Environment

Corporate and Regulatory Environment

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Teterboro, NJ
May 15, 2017

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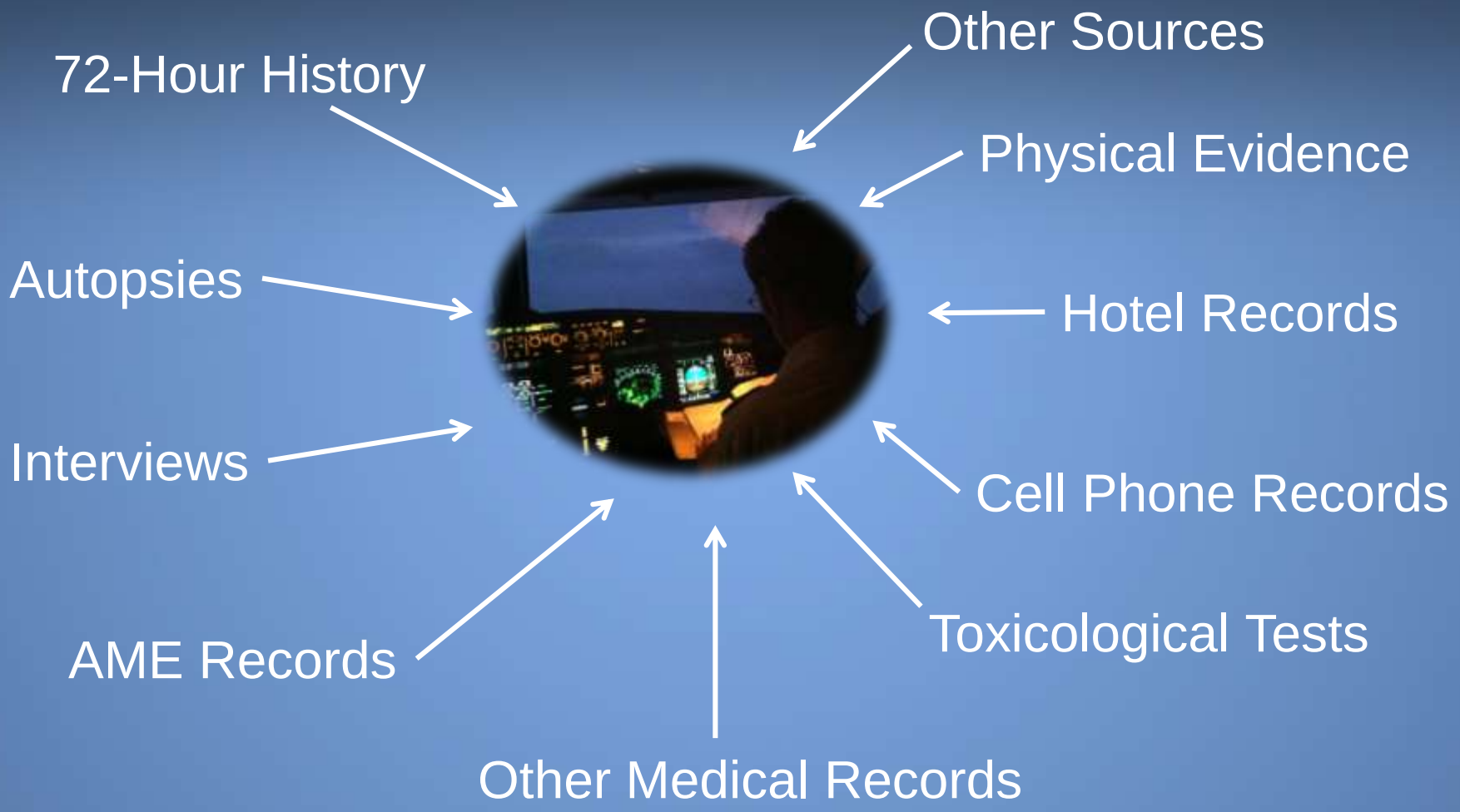
- The pilot-in-command's (PIC) attempt to salvage an unstabilized visual approach, which resulted in an aerodynamic stall at low altitude.

- Contributing to the accident was the PIC's decision to allow an unapproved second-in-command to act as pilot flying, the PIC's inadequate and incomplete preflight planning, and the flight crew's lack of an approach briefing.

Also contributing to the accident were Trans-Pacific Jets' lack of safety programs that would have enabled the company to identify and correct patterns of poor performance and procedural noncompliance and the Federal Aviation Administration's ineffective Safety Assurance System procedures, which failed to identify these company oversight deficiencies.

Potential Sources of Information



Thomson, GA
February 20, 2013

NTSB


28
1993
Google earth
Imagery Date: 1/29/2015 33°31'41.29" N 82°30'08.01" W elev 498 ft eye alt 4135

NTSB

Pilot activities

Night before trip		
	Went to bed	2100
	5 hours	
Day of trip		
	Woke up	0200
	Departed home	0230
	Arrived airport	0330
	Departed for Nashville	0406
	Arrived Nashville	0459*
	Lunch 14 hours	1500 – 1630*
	Passengers arrived	1918*
	Takeoff Nashville	1927*
	Crash at Thomson, GA	2005

* Times converted to EST

NTSB

Time	Cell phone activity
0808	Phone call - outgoing
0813	Phone call - outgoing
0902	Phone call - outgoing
1002	Text message - outgoing
1005	Text message - outgoing
1016	Text message - outgoing
1121	Text message - outgoing
1138	Phone call - outgoing
1234	Phone call - outgoing
1251	Phone call - outgoing
1300	Phone call - outgoing
1315	Phone call - outgoing
1317	Phone call - outgoing
1324	Phone call - outgoing
1330	Phone call - outgoing
1332	Phone call - outgoing
1404	Text message - outgoing
1432	Phone call - outgoing
1501	Phone call - outgoing
1503	Phone call - outgoing
1642	Phone call - outgoing

1 Incoming call

2 Incoming calls

2 Incoming calls

2 Incoming calls

2 Incoming calls

1 Incoming call

1 Incoming call

NTSB

National Transportation Safety Board

Loss of Control
Eurocopter AS350

Las Vegas, Nevada
December 7, 2011


Fuselage
and engine

Recommendation

Maintenance personnel should receive initial and recurrent training on maintenance human factors, including:

– a review of the causes of human error

– fatigue

Lockhart, TX
July 30, 2016

Pilot's Medications

- Prescribed 13 medications
  - Many likely not impairing
- Toxicology: 5 likely impairing medications
  - Three prescription
    - Cyclobenzaprine, diazepam, oxycodone
  - Two over-the-counter
    - Dextromethorphan, diphenhydramine

Asiana flight 214

- July 6, 2013
- San Francisco, California
- 3 Fatalities

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Probable Cause

- The flight crew's mismanagement of the airplane's descent during the visual approach
- The pilot flying's unintended deactivation of automatic airspeed control
- The flight crew's inadequate monitoring of airspeed
- The flight crew's delayed execution of a go-around after they became aware that the airplane was below acceptable glidepath and airspeed tolerances.

Contributing to the accident:

(1) the complexities of the autothrottle and autopilot flight director systems that were inadequately described in Boeing's documentation and Asiana's pilot training, which increased the likelihood of mode error

(2) the flight crew's nonstandard communication and coordination regarding the use of the autothrottle and autopilot flight director systems

(3) the pilot flying's inadequate training on the planning and executing of visual approaches

(4) the pilot monitoring/instructor pilot's inadequate supervision of the pilot flying

(5) flight crew fatigue which likely degraded their performance.

Aircraft Design Human Factors

NTSB

System Safety Order of Precedence*

1. Eliminate the hazard through Design/Engineering Features
   - Hazard is corrected and eliminated
2. Incorporate Guards/Safety Devices
   - Guards put up to decrease exposure
3. Provide Warning Devices
   - Warn personnel if you can't eliminate or control the hazard
4. Develop Procedures and Training

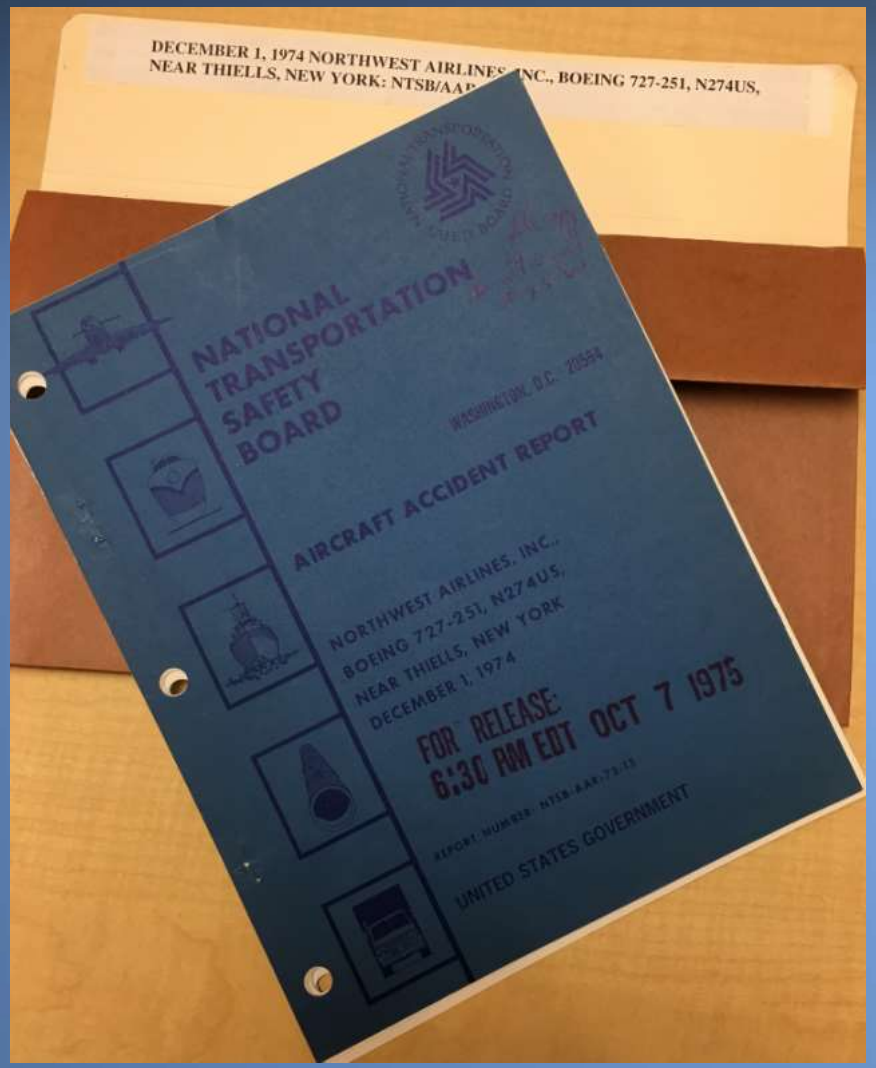
*Also know as "Hierarchy of Controls."

Source: MIL-STD-882E

ROBERT'S HF PREMISE # 1

If you design out the problem, you design out the problem.

<duh>


DECEMBER 1, 1974 NORTHWEST AIRLINES, INC., BOEING 727-251, N274US,
NEAR THIELLS, NEW YORK: NTSB/AAR
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594
AIRCRAFT ACCIDENT REPORT
NORTHWEST AIRLINES, INC.,
BOEING 727-251, N274US,
NEAR THIELLS, NEW YORK
DECEMBER 1, 1974
FOR RELEASE:
6:30 PM EDT OCT 7 1975
REPORT NUMBER: NTSB-AAR-75-13
UNITED STATES GOVERNMENT


PITOT STATIC HEAT
ACAMPS
0
1
P
S
T PROBE
AUX P
ELEV P
3
2
LEFT
RIGHT
PITOT
STATIC
TEMP PROBE
ELEV PITOT
PITOT OFF
PITOT
STATIC
AUX PITOT
ELEV PITOT
OFF
ON
CAPT
F/O
AUX

NTSB

ROBERT'S HF PREMISE # 2

If you design something with enough complexity, don't be surprised if someone can't use it when they really need it.

American 383, October 28, 2016

Rejected takeoff

Evacuation


BOEING
PILOT
PUSH TO TALK
AMERICAN AIRLINES, INC
AA
S/N


PUSH TO TALK


LIFT HANDSET

ROBERT'S HF PREMISE # 3

If you don't account for human error, you, yourself, have made a very basic human error.

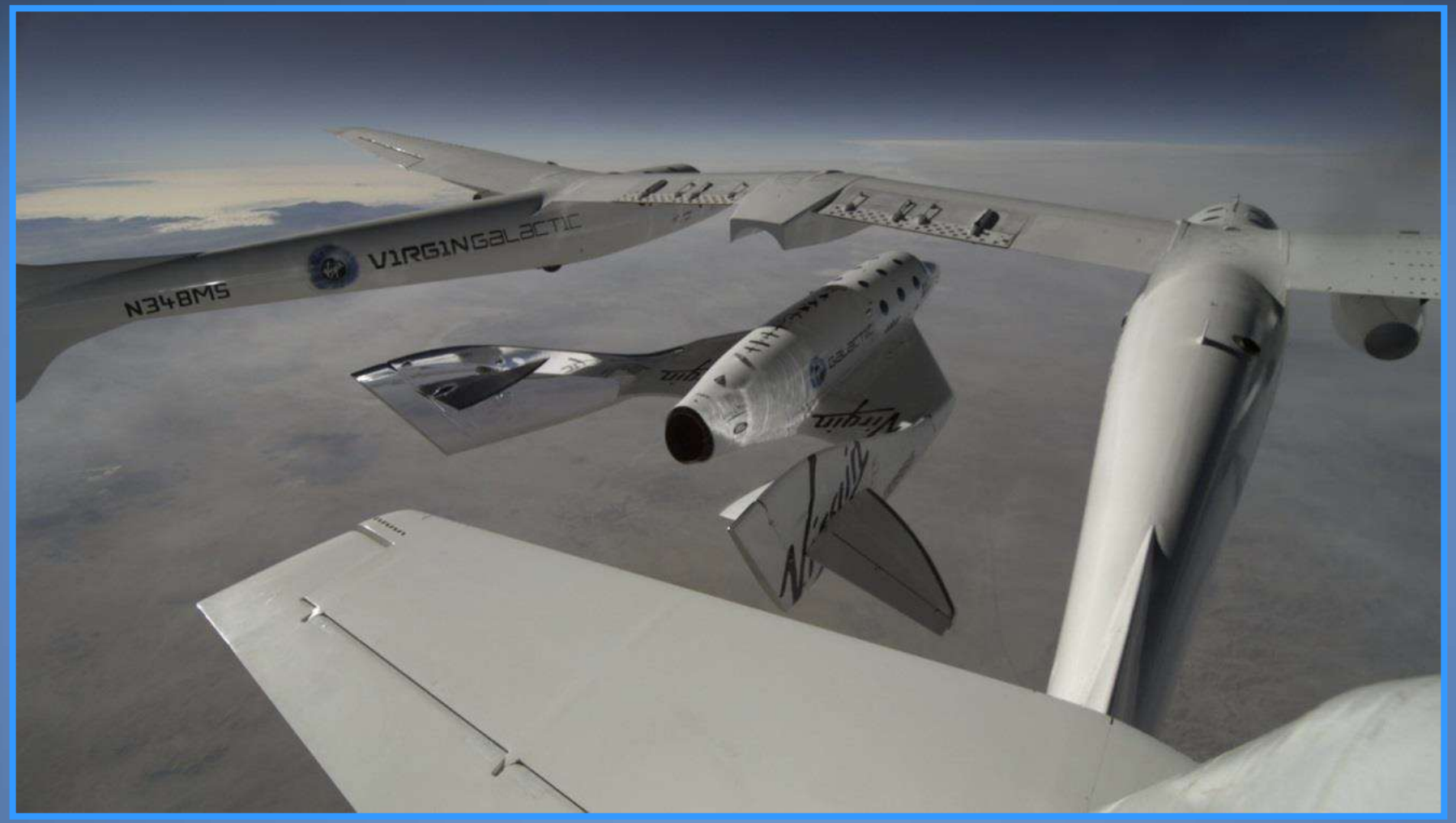
In-Flight Breakup During Test Flight

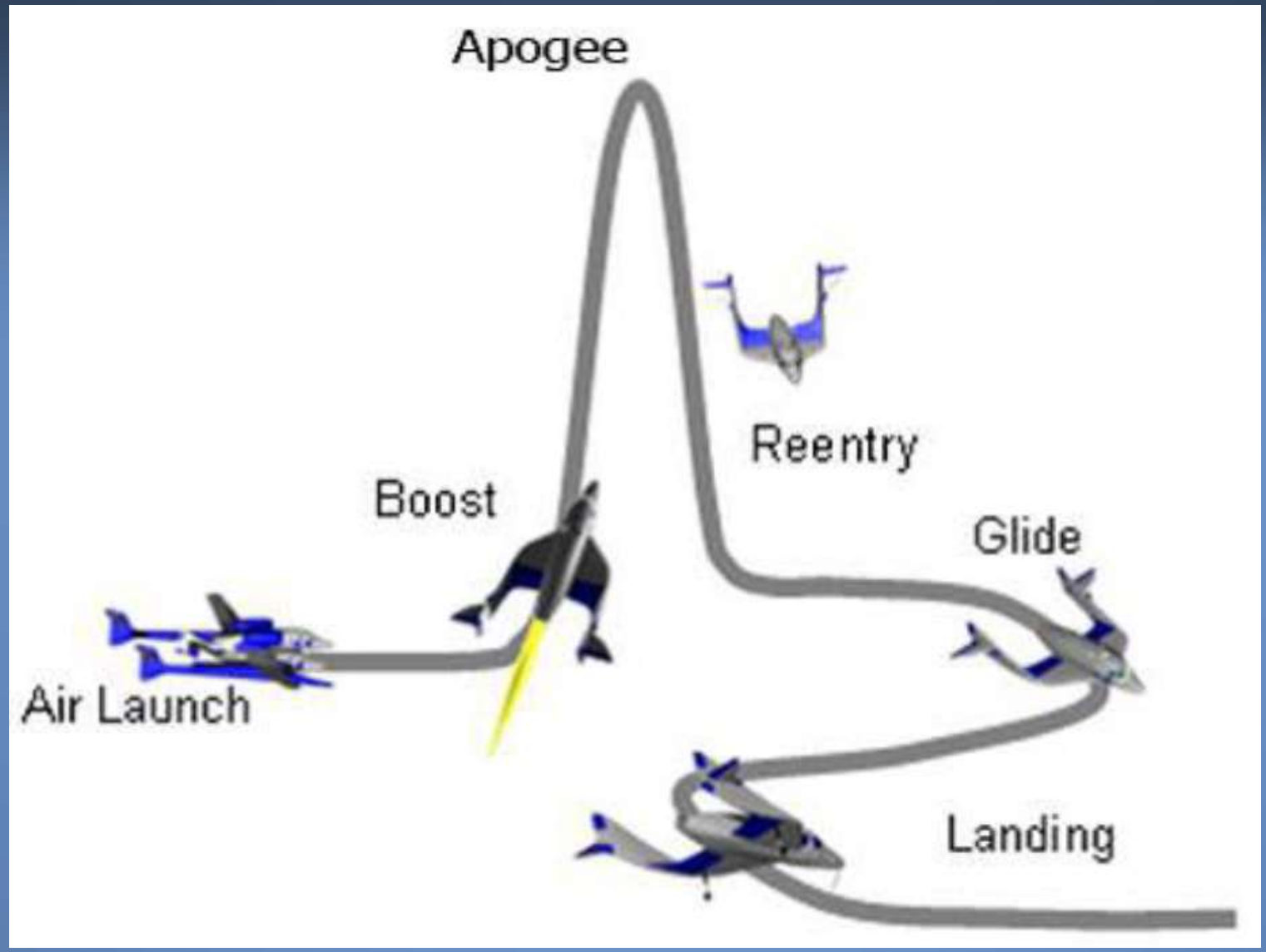
October 31, 2014

SpaceShipTwo

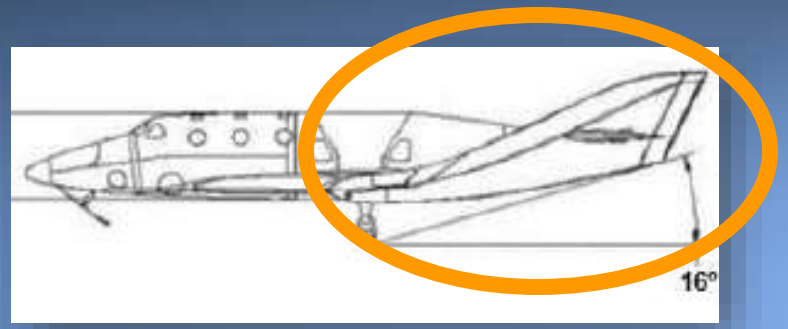
NTSB


N348MS
N339SS
N348MS

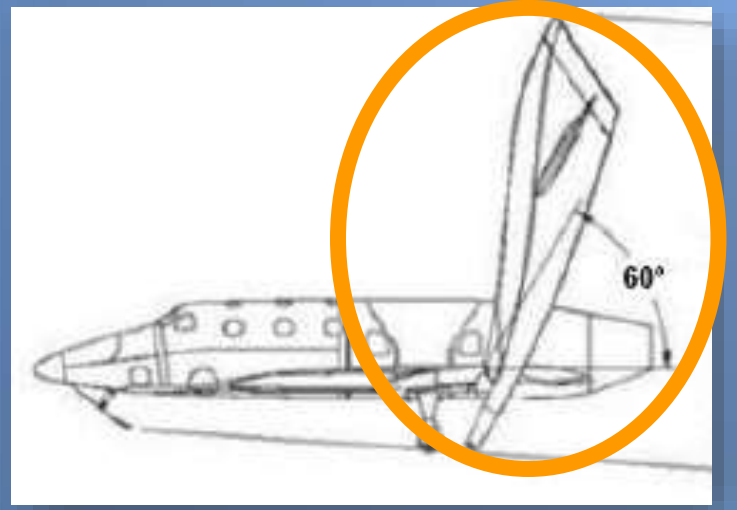

N348MS
VIRGIN GALACTIC


Apogee
Reentry
Boost
Glide
Air Launch
Landing

SpaceShipTwo Feather System



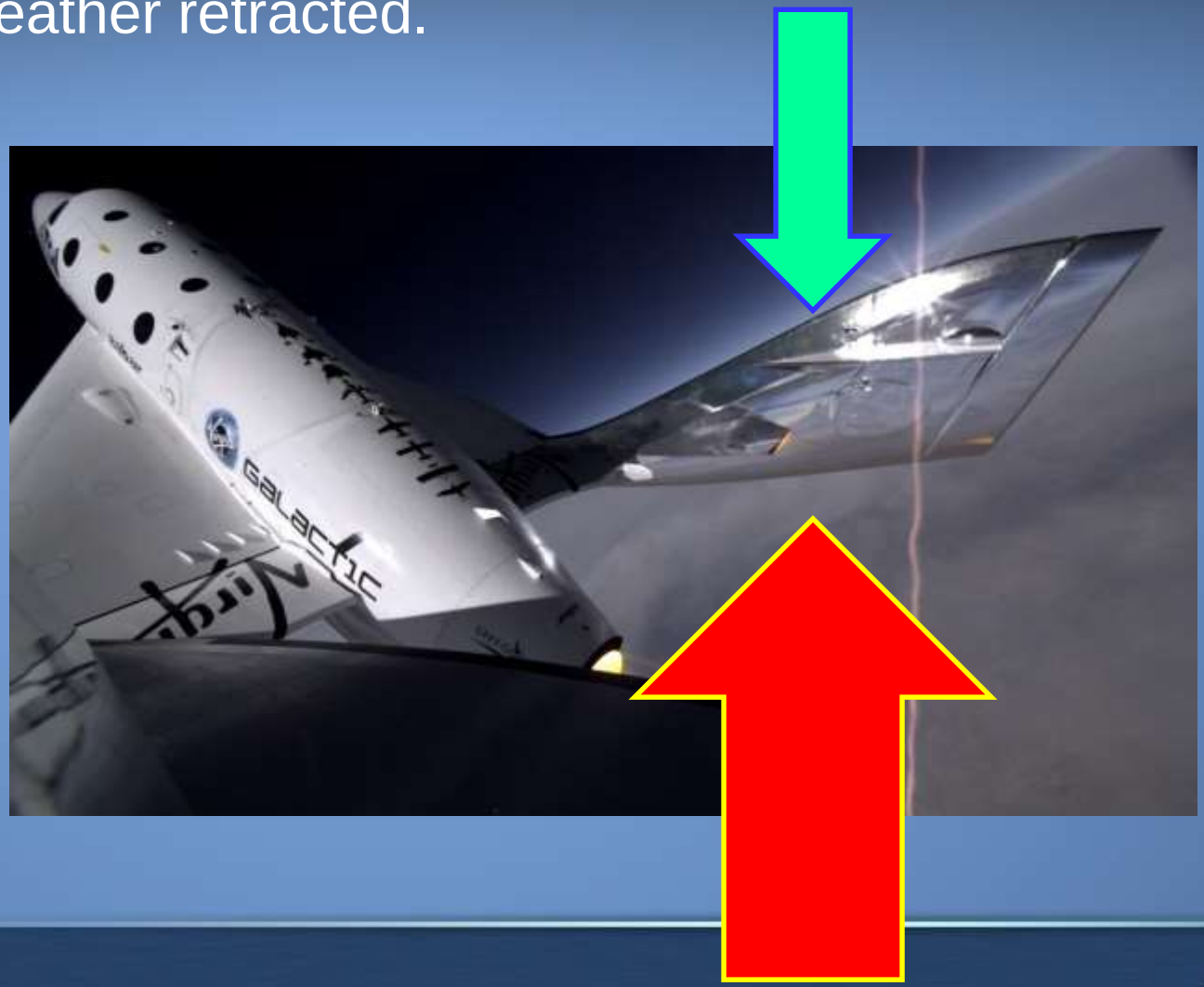
Feather retracted



Feather extended

PROBLEM: During the transonic region, the upward aerodynamic forces acting on the feather exceeded the ability of the feather actuators to keep the feather retracted.

SOLUTION: Provide mechanical locks to keep feather retracted during this region.



Feather Lock Handle

Feather Locked

Lock

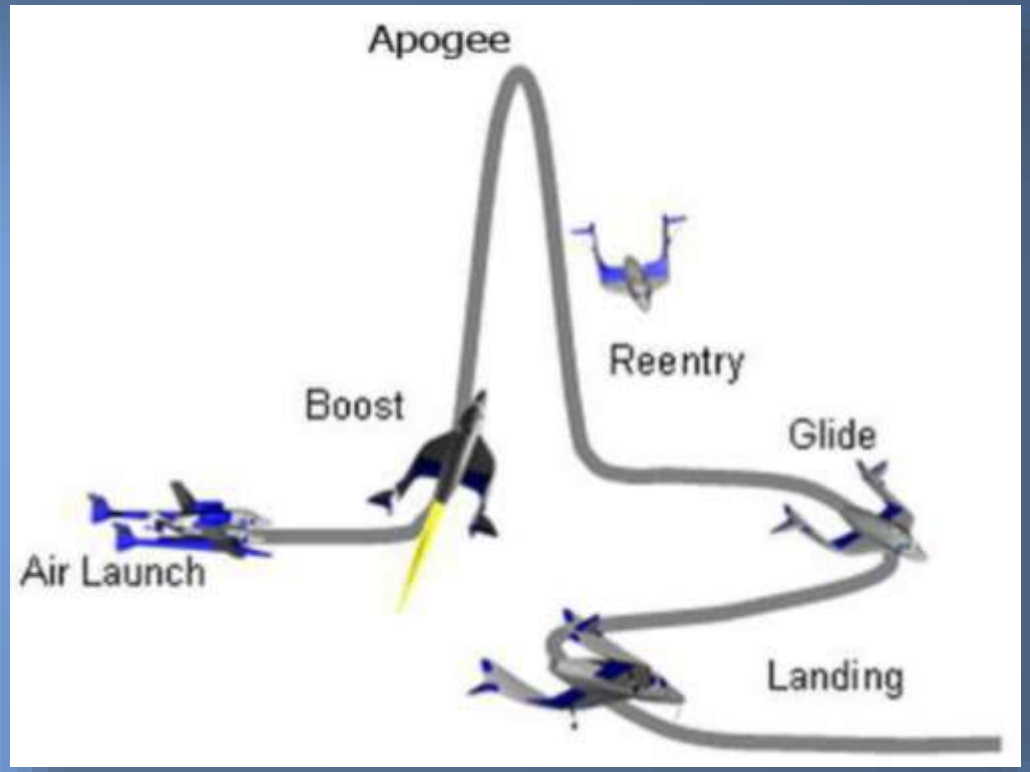
Unlock

Feather Unlocked

NTSB

PROBLEM: If feather could not be unlocked, it would pose a very high risk (probably catastrophic) reentry.

SOLUTION: Unlock feather at 1.4 Mach.

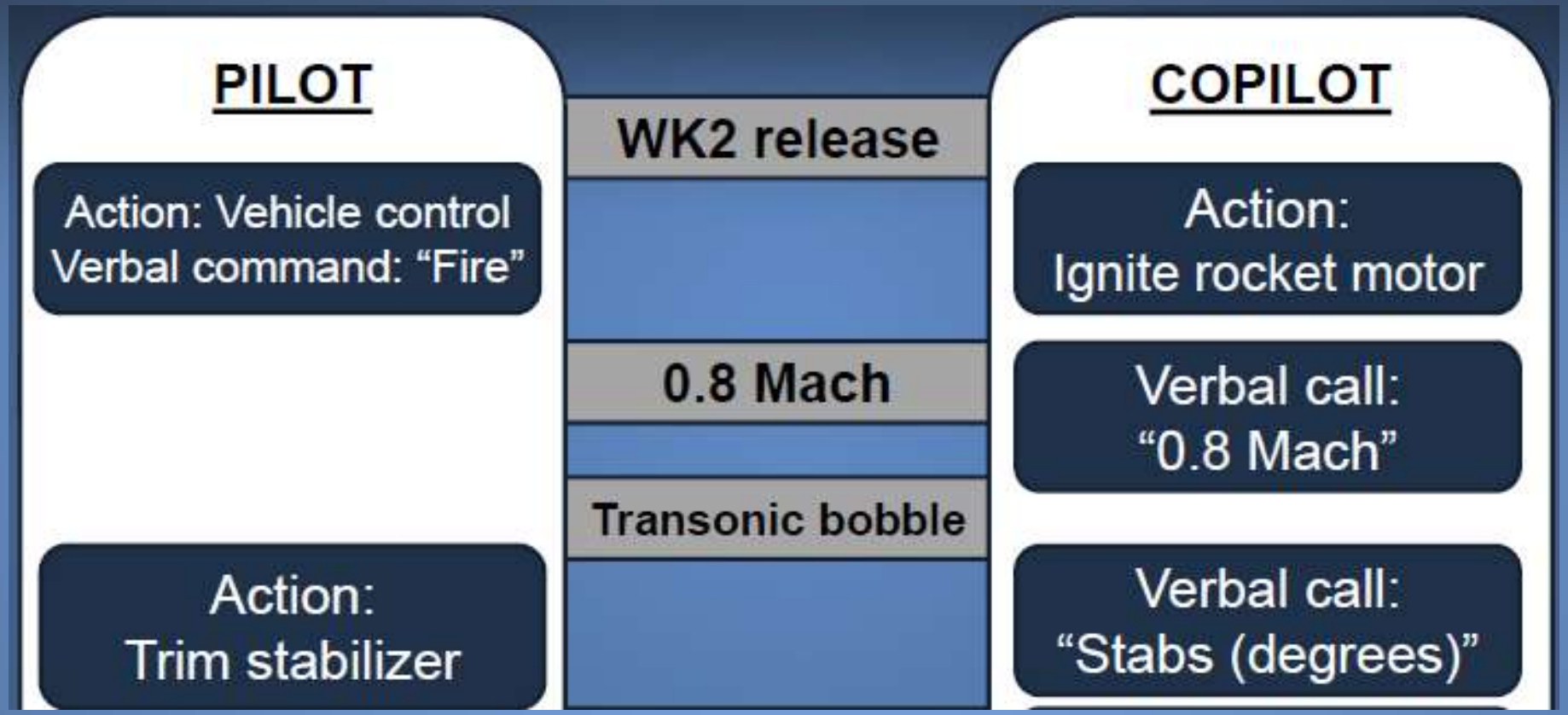


If not unlocked at 1.5 Mach, cockpit alert.
If not unlocked at 1.8 Mach, mission abort.

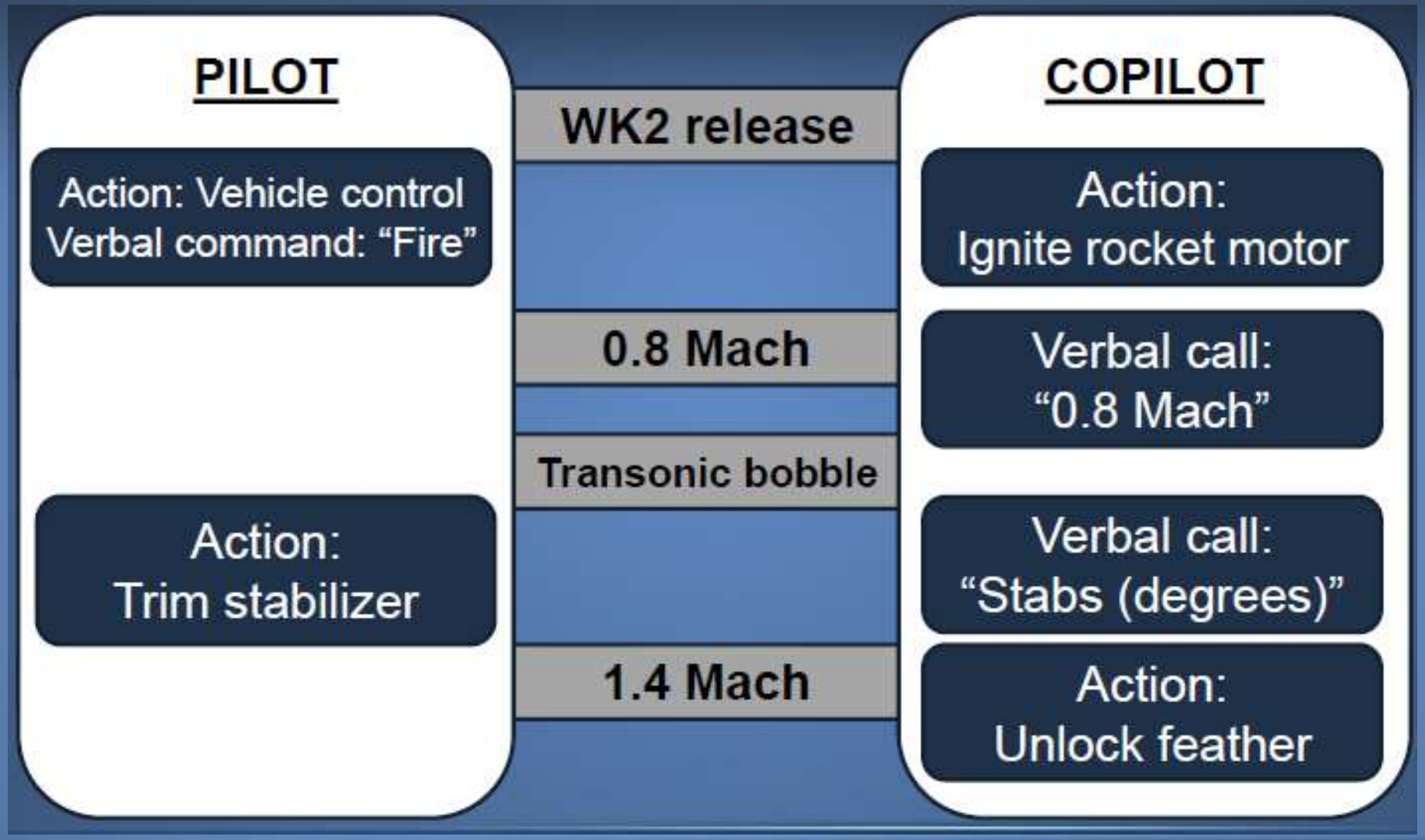
Specified Flight Crew Procedures

Specified Flight Crew Procedures

Specified Flight Crew Procedures



Specified Flight Crew Procedures



What actually occurred

- Copilot made 0.8 Mach callout
- At 0.82 Mach, called out “unlocking” and moved feather handle to unlocked position
- Video and telemetry stopped

DCA15MA019

SCALED COMPOSITES

SPACESHIPTWO

N339SS

POWERED FLIGHT #4

The investigation found

- High emphasis on making sure feather was unlocked at 1.4 Mach.
  - Cockpit visual and aural alerting
  - Training and procedures
  - Mission abort if not unlocked by 1.8 Mach
- Not great concern placed on low speed unlocking.
  - Relied on pilots to do it right

- A single-point mechanical failure with catastrophic consequences would be unacceptable.
- However, Scaled Composites failed to consider that a single human error could be catastrophic.

NTSB Finding

"By not considering human error as a potential cause of uncommanded feather extension on the SpaceShipTwo vehicle, Scaled Composites missed opportunities to identify the design and/or operational requirements that could have mitigated the consequences of human error during a high workload phase of flight."

Probable Cause of the Accident

- “Scaled Composites’ failure to consider and protect against the possibility that a single human error could result in a catastrophic hazard to the SpaceShipTwo vehicle.
- This failure set the stage for the copilot’s premature unlocking of the feather system as a result of time pressure and vibration and loads that he had not recently experienced, which led to uncommanded feather extension and the subsequent aerodynamic overload and in-flight breakup of the vehicle.”

NTSB Recommendation

Develop and issue human factors guidance for use during the design and operation of crewed vehicles.

National Transportation Safety Board